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EXTERNAL COMPARISONS OF REPROCESSED SBUV/TOMS OZONE DATA

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ABSTRACT

Ozone retrievals from the Solar Backscatter Ultraviolet (SBUV) Instrument on-board the Nimbus-7 Satellite have been reprocessed using an improved internal calibration. The resulting data set covering November, 1978 through January, 1987 has been archived at the National Space Science Data Center in Greenbelt, Maryland. The reprocessed SBUV total ozone data as well as recalibrated Total Ozone Mapping Spectrometer (TOMS) data are compared with total ozone measurements from a network of ground based Dobson spectrophotometers. The SBUV also measures the vertical distribution of ozone, and these measurements are compared with external measurements made by SAGE II, Umkehr, and Ozonesondes. Special attention is paid to long-term changes in ozone bias.

TOTAL OZONE COMPARISONS

Eight years of Dobson total ozone data have been obtained from the WODC, Toronto, Canada covering the period from November 1978 through October, 1986. Dobson comparisons presented earlier for the SBUV and TOMS (Fleig et al., 1988) have been redone using the recalibrated data. Methods identical to those used previously gave the results presented in Figure 1 for SBUV and Figure 2 for TOMS. These figures show yearly average percent bias (SBUV or TOMS - Dobson) for a select subset of the Dobson Network. The stations selected give uniform temporal coverage over the period considered. Any stations providing less than 10 coincidences in any year are not used. Linear regression of the SBUV-Dobson and TOMS-Dobson bias from the variance weighted comparisons indicate no significant drift relative to Dobson. The slopes derived by the regression are -0.09 _ 0.11 % per year for SBUV and -0.11 ± 0.11 % per year for TOMS (95% confidence). The Dobson data have been adjusted in this comparison to values equivalent to the use of more recent ozone absorption coefficients (Paur and Bass, 1985). TOMS total ozone measurements are seen to have a positive bias

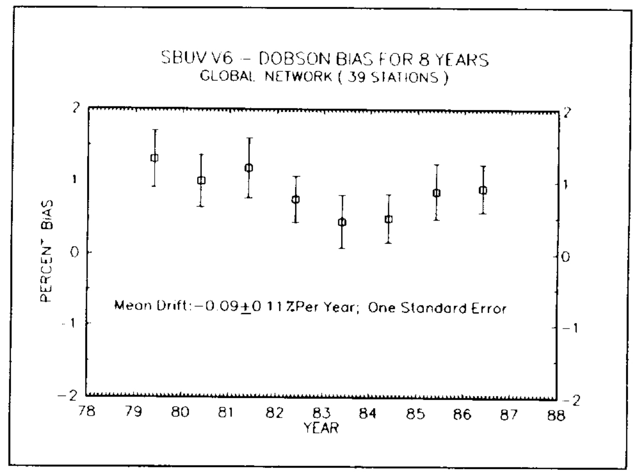

Fig. 1 Yearly mean percent ozone bias SBUV Version 6 - 39 station Dobson network. Error bars indicate ± one standard error.

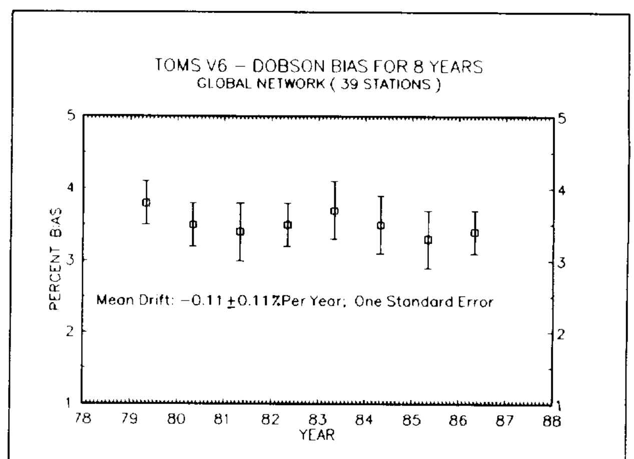

Fig. 2 Yearly mean percent ozone bias TOMS Version 6 - 39 station Dobson network. Error bars indicate ± one standard error.

with respect to SBUV and Dobson. This may be due to initial calibration uncertainty. Though not statistically significant in this comparison, the differences in SBUV-Dobson and TOMS-Dobson bias after the eruption of El Chichon in April, 1982 may be associated with the scan angle dependent effects of volcanic aerosols on TOMS retrievals. The mid-off-nadir samples for TOMS are biassed upward in total ozone relative to the nadir samples [Torres and Herman, 1992].

SBUV PROFILE COMPARISONS

Eight years of data from the SBUV were collocated in time and space with all of the Umkehr station and balloonsonde reports available from the World Ozone Data Center. Criteria for matching were that SBUV and ground station data be from the same day and that the center of the SBUV field of view be within 1° of latitude of the station. Longitudinal separation was varied from 5° for Umkehr layers 1-4 up to a maximum of 10° for layers 5 and above. This variable window, a result of trial and error, represents the best compromise between data volume and comparison noise that results from large longitudinal separation.

The Umkehr data is strongly affected by the presence of aerosols, particularly after the eruption of El Chichon in April 1982. A correction for this effect has been developed (DeLuisi et al., 1988) which is in the form of monthly correction factors for stations in the latitude band 30-50° north. From this latitude band, a group of five stations have been selected for providing the greatest temporal coverage over the eight year period. The stations selected were Tateno (36.1 N), Boulder (40.0 N), Lisbon (38.8 N), Arosa (46.8 N), and Belsk (51.8 N). A sample time series of the monthly mean percent bias between SBUV and corrected Umkehr ozone amount in layer 8 from Arosa is shown in Figure 3.

The Balloonsonde Network is composed of eight stations which were also selected for giving the best temporal coverage over the time period. These stations are Edmonton (53.6 N), Resolute (74.7 N), Goose Bay (53.2 N), Churchill (58.8 N), Hohenpeissenberg (47.8 N), Lindenberg (52.2 N), Legionowo (52.2 N), and Prague (50.2 N).

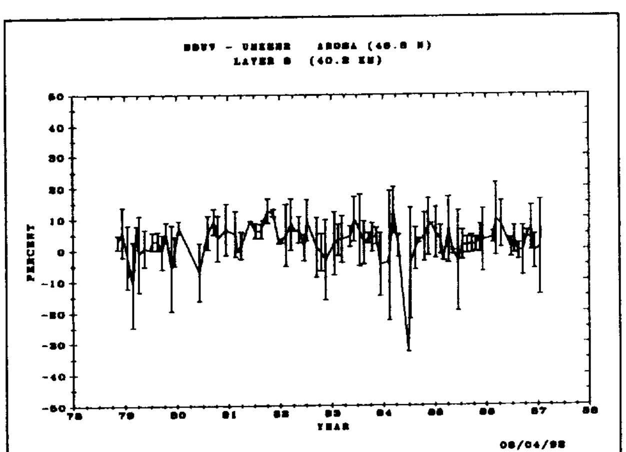

Fig. 3 Monthly mean percent layer ozone bias SBUV Version 6 - Umkehr for coincidences over the station at Arosa (1.98 - 3.96 mb). Error bars indicate ± one standard error.

In order to remove any residual seasonal variation in the bias and derive the drift between the long term trend of two time series, a linear regression model has been fit to the percent difference SBUV - external data with the addition of annual and semi-annual terms. The overall drift of SBUV relative to a given system is then computed as the mean of the slopes of the individual regressions for each station in the system. A 95% confidence limit is computed based on the standard error of this mean. The results of the statistical analysis applied to the balloonsonde and Umkehr data are summarized in Table 1 (containing biases) and Table 2 (linear drift). The Umkehr network used for this comparison has only five stations, and two stations had half the number of comparison as did the other three. A second method of comparison was calculated by applying the regression against all of the Umkehr soundings treated as coming from a single system. This effectively reduced the impact of the Lisbon and Belsk Umkehr data. The 95% confidence limit in this regression is considerably lower in the upper layers than the one based on the standard error of the network mean. This is the result given in Table 2. The re-calibrated SBUV data show no sig-

Table 1 SBUV Profile Mean Bias Relative to External Measurements % (95% Confidence)

Umkehr Layer	Pressure (mb)	SBUV Balloon	SBUV Umkehr	SBUV SAGE	Height (km)
9	1.40	———	———	-0.6 (1.9)	45.5
8	2.80	———	0.6 (0.3)	-0.1 (1.6)	40.2
7	5.60	———	-4.2 (5.0)	-0.2 (1.2)	35.2
6	11.2	0.4(3.5)	-9.0 (3.1)	-3.3 (1.8)	30.4
5	22.4	-3.6(7.1)	2.4 (1.7)	0.2 (2.7)	25.8
4	44.8	-7.8(4.4)	4.6 (5.3)	-1.7 (4.6)	21.3
3	89.6	16.8(9.8)	22.7 (6.6)	———	17.0
2	179	3.6(7.5)	-30.4 (12.3)	———	12.5
2-4	63.3	———	6.6 (4.0)	———	17.0

Table 2 SBUV Profile Linear Drift Relative to External Measurements %/year (95% Confidence)

Umkehr Layer	Pressure (mb)	SBUV Balloon	SBUV Umkehr	SBUV SAGE	Height (km)
9	1.40	———	———	1.8 (0.8)	45.5
8	2.80	———	-0.2 (0.2)	1.1 (0.7)	40.2
7	5.60	———	0.4 (0.2)	0.7 (0.5)	35.2
6	11.2	-2.1 (2.3)	0.0 (0.1)	0.4 (0.4)	30.4
5	22.4	0.0 (0.9)	-0.3 (0.1)	-0.2 (0.5)	25.8
4	44.8	0.8 (1.8)	0.2 (0.2)	0.2 (0.8)	21.3
3	89.6	1.0 (1.7)	-0.1 (0.3)	———	17.0
2	179	-0.8 (2.4)	-2.6 (1.0)	———	12.5
2-4	63.3	———	-0.2 (0.2)	———	17.0
Years		8	8	2.25	

nificant drift relative to the balloonsonde and Umkehr measurements, except in Umkehr Layer 7 where a significant upward drift in SBUV ozone is identified relative to Umkehr. Some significant biases appear to exist in the lower layers however.

Also shown in Tables 1 and 2 are the results of an SBUV-SAGE II comparison. The SAGE II instrument was launched in October, 1984 so only a little over two years of the data overlap with the SBUV data considered. These data were obtained from the National Space Science Data Center (NSSDC) in Greenbelt, Maryland. The data were analyzed in a fashion analogous to the ground based networks except that instead of individual stations 10 degree latitude zones were considered. The coincidence criteria were the same as above except that the time coincidence was restricted to the nearest half day to avoid incorrect coincidences near the 180th meridian. The same regression model described above was used to derive the drift of SBUV relative to SAGE II in each zone, and the overall drift is the mean across the latitude bands with the 95% confidence limits based on the standard error of the mean. The SBUV and SAGE II agree quite well in terms of bias, but a statistically significant drift results in Umkehr layer 9. Since only 2.25 years of data are analyzed however, this drift may only amount to a total of about 4% over the period of the comparison. Surfaces indicating the latitudinal and height dependence in the SBUV-SAGE II bias and drift are shown in Figures 4 and 5 respectively. They indicate possible systematic differences between SBUV and SAGE II in the lower layers and 80 degrees south latitude. These differences are not understood at this time.

Figure 6 shows a sample time series of the sum of ozone amounts in Umkehr layers 2-4 measured by SBUV and balloonsonde at Hohenpeissenberg (47.5 N). It is evident in this plot that the SBUV system provides ozone information in the lower layers. Two stages in the development of that information are represented in the graph. The dotted line is the first

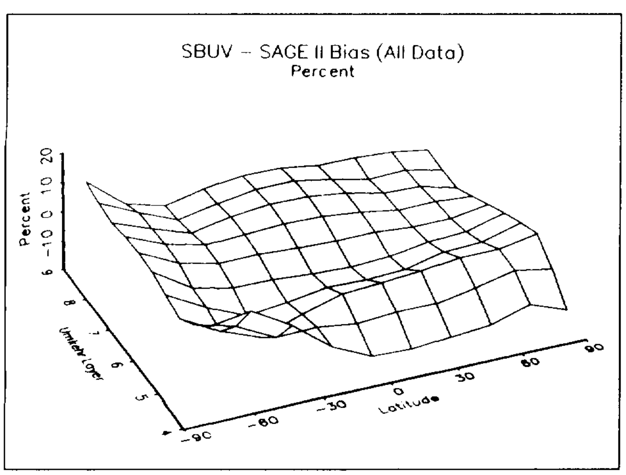

Fig. 4 Height-latitude surface of the mean percent layer ozone bias SBUV Version 6 - SAGE II. Central layer pressures given in Table 1.

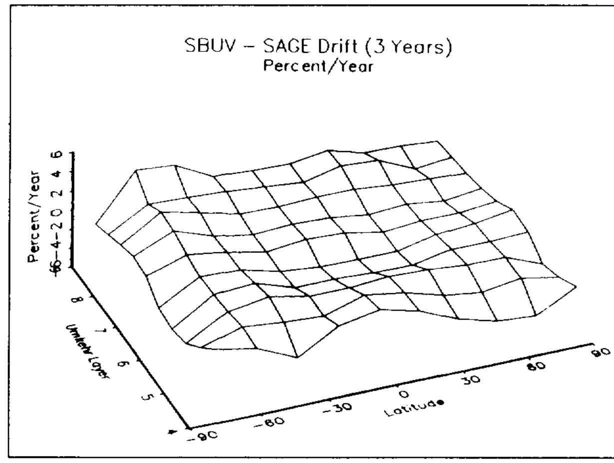

Fig. 5 Height-latitude surface of the drift in mean percent layer ozone bias SBUV Version 6 - SAGE II. Central layer pressures given in Table 2.

guess ozone which is derived from the SBUV total ozone measurement and an ozone climatology based on balloon and SAGE II measurements, and the solid line is the final retrieval. It is clear that most of the variance in the sum of layers 2-4 is explained by the total ozone measurement and the climatology. That information is not necessarily appropriate for the determination of long term trend (WMO/NASA Ozone Trends Panel Report, 1988) since long term changes in ozone may not occur in the same vertical distribution as the shorter term variability represented in the climatology, but it is useful in tracking short term changes in the lower layers. However, some additional information is obtained by the retrieval. The correlation coefficient for SBUV comparisons at Hohenpeissenberg improves in the final retrieval over the first guess from 0.9 to 0.93.

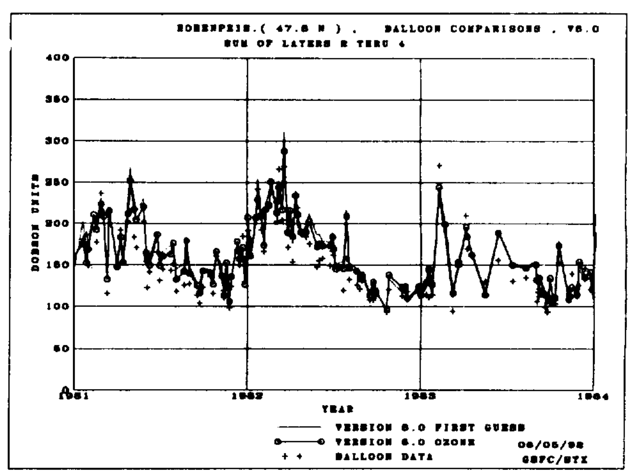

Fig. 6 Comparison of layer ozone amounts given by SBUV Version 6 first guess and final retrieval with Balloonsondes from Hohenpeissenberg (31.7 - 253 mb). Illustrates ability of SBUV retrieval to provide lower level profile information at course resolution.

CONCLUSIONS

Comparisons of re-calibrated SBUV total ozone and layer ozone amounts with the ground based measurements of Dobson, Umkehr, and Balloonsonde indicate that no significant long-term drift is present during the time period from November, 1978 through January, 1987, except in Umkehr Layer 7 where a significant upward drift in SBUV ozone is identified relative to Umkehr. These SBUV data have been archived at the National Space Science Data Center, and are available for distribution.

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